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April 30, 2007

Mr. Steven Winnett
United Stated Environmental Protection Agency Region I
Mail Code CWQ
One Congress Street
Boston, MA 02114-02023

Subject: Deliverable for Task 2c for New Hampshire TMDL Project; EPA-SMP-07-002

Dear Mr. Winnett,

ENSR is pleased to forward to the United States Environmental Protection Agency (USEPA) Region 1 the next deliverable for the **New Hampshire Total Maximum Daily Load (TMDL) Development** project (EPA –SMP-07-002). This deliverable completes the requirements of Task 2c "Calculate TMDL Values" as part of Task 2 Development of Acid Pond TMDLs. We are submitting the following (two hardcopies and electronic submittal) information: (1) this narrative letter; (2) Table 1 "*Critical Load of Acidity for New Hampshire Acid-Impaired Ponds*"; and (3) Table 2 "*Critical Load Calculations for New Hampshire Acid-Impaired Ponds.*" A summary of the supporting water quality data is provided in spreadsheet provided in the Appendix.

Introduction

As part of its contract with USEPA, Region 1, ENSR is compiling and synthesizing the watershed and water chemistry data required for development of TMDLs for 266 acid-impaired waterbodies in New Hampshire. This waterbodies were listed as acid-impaired under New Hampshire's 2004 Clean Water Act (CWA) Section 303(d) list because pH values did not meet (were less than) the State's surface water quality criterion for protection of aquatic life. These lakes were identified because, of 10 samples taken during the last 10 years, a minimum of three samples did not meet the criterion of pH 6.5.

The complete suite of 266 waterbodies identified for the Acid TMDL study consists of 150 lakes, 2 impoundments, and 114 associated beaches. At the request of NHDES, six additional waterbodies and two more beaches were added to this set (e-mail from Margaret Foss, NHDES; dated March 13, 2007). Table 1 provides a list of the cumulative 158 lakes and impoundments, listed according to their associated Assessment Unit (AU) codes. For purposes of this project, these waterbodies are collectively referred to as ponds.

As directed by the New Hampshire Department of Environmental Services (NHDES), ENSR has used the Steady State Water Chemistry (SSWC) model originally developed by Henrikson and Posch (2001), with the assumptions and modifications adopted by the Vermont Department of Environmental Conservation (VTDEC), to calculate critical loads and develop TMDLs. This method of determining critical loads is based on water chemistry, annual surface runoff, and specified target Acid Neutralizing Capacity (ANC) and is consistent with the approach previously developed by New Hampshire for acid TMDLs for 65 ponds and approved by Region 1 (i.e., NHDES, 2004).

One important model component that is different from the NHDES (2004) work is the revised critical ANC target concentration ($[ANC]_{limit}$) developed for use in the present TMDL process. The $[ANC]_{limit}$ is based on the lowest ANC concentration presumed not to potentially damage selected biota (Henricksen and Posch, 2001). The $[ANC]_{limit}$ was recalculated on the basis of the pH-ANC relationship developed in Project Task 2b (see memo to Steve Winnett dated March 27, 2007). The new $[ANC]_{limit}$ was determined to be **6.24** mg/L (125 ueq/L) at pH 6.5. This value was reviewed and approved by NHDES (e-mail from Margaret Foss, NHDES; dated March 30, 2007) and was inputted into the SSWC model as a means of identifying ponds which are not in compliance with NHDES standards.

Water quality data for base cations (Ca, Mg, K, Na) and anions (Cl, SO_4, NO_3) were obtained by ENSR from the NHDES OneStop Data Retrieval Site (http://www.des.state.nh.us/OneStop.htm). Specifically, data were obtained by querying the Environmental Monitoring Database at the various ponds. Queries were preferentially obtained from the period of 01/01/1996 through 01/01/2008 (the default end date in the database query page), unless no data were available for the pond; in which case, more historic data were obtained. Outputs from the database were formatted as Microsoft Excel files and were then placed in a Microsoft Access database, constructed by ENSR. Water quality data used to support the SSWC calculations are provided in Appendix A, which also identifies those ponds which required application of historic data.

Determination of Critical Loads

Critical loads (CL_{ac}) were determined for the 158 acid-impaired ponds. The CL_{ac} is the flux of acid anions arising from acid deposition that results in the target ANC_{limit} when subtracted from the pre-industrial flux of base cations according to the following equation:

$$\mathbf{CL_{ac} = ([BC']_o - [ANC]_{limit}) * Q}$$

where: CL_{ac} = Critical load of acidity;

$([BC']_o$ = pre-industrial concentration of base cations (corrected for sea salts);

$[ANC]_{limit}$ = critical ANC concentration; and

Q = annual runoff (m/yr).

Further details on the SSWQ are provided in Henriksen and Posch (2001), Henriksen, Dillon and Aherne (2002) and NHDES (2004). The SSWC calculations were conducted using the spreadsheet, assumptions and equations provided by Heather Pembrooke (VTDEC) whose cooperation and insights are gratefully acknowledged.

Table 2 provides a summary of the input parameters and secondary calculations (e.g., correction for sea salts) needed for determination of CL_{ac}. Watershed-specific runoff (Q) was previously determined as part of Project Task 2a using the methods described in the first deliverable (see memo to Steve Winnett dated February 28, 2007).

Results

The calculated critical loads for the 158 acid-impaired ponds are presented in Table 1. This table includes both the critical load calculated as an annual flux ($meq*m^{-2}*yr^{-1}$) and as a daily flux ($meq*m^{-2}*dy^{-1}$). The latter was calculated by simply dividing the annual flux by 365. There were 98 ponds with positive CL_{ac} values and 60 with negative values. The negative values indicate ponds which have insufficient buffering capacity to absorb the expected annual acid deposition loads and still achieve the protective $[ANC]_{limit}$ of 125 ueq/L.

The annual values range from a low of -1659 $meq*m^{-2}*yr^{-1}$ in Stevens Pond (Manchester) to a maximum of 244 $meq*m^{-2}*yr^{-1}$ in Round Pond (Pittsburg). The average CL_{ac} value was 1.95 $meq*m^{-2}*yr^{-1}$, but due to the large variation between ponds for this term, perhaps the more telling statistical indicator is the median value of 15.53 $meq*m^{-2}*yr^{-1}$.

Eight ponds in Table 1 had relatively larger magnitude negative CL_{ac} values (i.e., less than -70 $meq*m^{-2}*yr^{-1}$). Further inspection of the supporting water quality data in Table 2 suggest that these very low values are driven by the high levels of chloride (Cl^-) found in these waterbodies (>20 mg/L) which leads to a large correction of the base cation term [BC] for marine (i.e., sea salt) influences. Since the SSWC assumes that all Cl^- is due to sea salt deposition, an influx of Cl^- due to anthropogenic sources (principally road salt) could lead to an overcorrection of the base cation term.

A quick inspection of the shoreline areas around some of these ponds (e.g., Stevens Pond, Horseshoe Pond (Merrimack), Hermit Lake (Sanbornton), Little Sunapee Lake (New London)) suggest that runoff containing road salt from adjacent major highways and interstates may be responsible. However, it is more difficult to ascribe this source to the other lakes (e.g., Massasecum Lake (Bradford), Mountainview Lake (Sunapee), Saltmarsh Pond (Gilford), Sunset Lake (Greenfield)). Further investigation may be necessary to identify whether anthropogenic sources are driving the CL_{ac} values in these lakes.

The CL_{ac} values calculated in for Task 2d are more extreme in range and more negative than those previously calculated for acid-impaired ponds in New Hampshire (NH DES, 2004). In that study the CL_{ac} values ranged from -146.5 to 105.6 $meq*m^{-2}*yr^{-1}$; with only 5 lakes of the 65 studies providing negative values. The difference from the present study is probably related, in some measure, to the increase in the $[ANC]_{limit}$ from 50 to 125 ueq/L.

The pond-specific critical loads developed for Project Task 2c will be incorporated into the TMDL process by inclusion of allocations and margin of safety (MOS) factors and will be presented as part of Project Task 2e Draft TMDL Report.

Please do not hesitate to contact ENSR with any questions regarding the attached table and spreadsheets or further clarification on our methods for preparation or presentation of these data.

Sincerely yours,

David F. Mitchell

Don Kretchmer

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Project files

REFERENCES

Henriksen, A. and M. Posch. 2001. *Water, Air, and Soil Pollution: Focus* 1:375-398.

Henriksen, A., Dillon, P., and J. Aherne. 2002. *Can. J. Fish Aquat. Sci.* 59:1287-1295.

New Hampshire Department of Environmental Services. 2004. *Total Maximum Daily Load (TMDL) for 65 Acid Impaired New Hampshire Ponds. Final Report.* NHDES, Concord, NH.

Table 1. Critical Loads of Acidity for New Hampshire Acid-Impaired Ponds

Count	Pond ID	Pond Name	Town	Yearly Critical Load meq/m²/yr	Daily Critical Load meq/m²/day
1	NHIMP700060302-02	HAYWARD BROOK - MORRILL POND	CANTERBURY	-14.83	-0.04
2	NHIMP700060502-01	UNKNOWN RIVER - DURGIN POND OUTLET	NORTHWOOD	-28.83	-0.08
3	NHIMP700061403-04	POWWOW RIVER - POWWOW POND	KINGSTON	56.11	0.15
4	NHLAK600020202-01	FALLS POND	ALBANY	39.60	0.11
5	NHLAK600020302-01-01	ECHO LAKE	CONWAY	-53.98	-0.15
6	NHLAK600020303-03	IONA LAKE	ALBANY	40.87	0.11
7	NHLAK600020303-05	BIG PEA PORRIDGE POND	MADISON	-8.05	-0.02
8	NHLAK600020303-06	MIDDLE PEA PORRIDGE POND	MADISON	-37.13	-0.10
9	NHLAK600020303-07-01	PEQUAWKET POND	CONWAY	75.45	0.21
10	NHLAK600020303-09	WHITTON POND	ALBANY	-24.55	-0.07
11	NHLAK600020604-03	MOORES POND	TAMWORTH	36.93	0.10
12	NHLAK600020701-02	LOWER BEECH POND	TUFTONBORO	-6.36	-0.02
13	NHLAK600020701-04	UPPER BEECH POND	WOLFEBORO	9.81	0.03
14	NHLAK600020702-01	DAN HOLE POND	TUFTONBORO	34.30	0.09
15	NHLAK600020703-03	PINE RIVER POND	WAKEFIELD	41.33	0.11
16	NHLAK600020703-04	WHITE POND	OSSIPEE	5.29	0.01
17	NHLAK600020801-01	BLUE POND	MADISON	29.39	0.08
18	NHLAK600020801-05	MACK POND	MADISON	74.38	0.20
19	NHLAK600020801-06-01	SILVER LAKE	MADISON	35.50	0.10
20	NHLAK600020802-04-01	OSSIPEE LAKE	OSSIPEE	61.97	0.17
21	NHLAK600020803-01-01	LOWER DANFORTH POND	FREEDOM	68.31	0.19
22	NHLAK600020803-01-02	MIDDLE DANFORTH POND	FREEDOM	102.92	0.28
23	NHLAK600020803-03	UPPER DANFORTH POND	FREEDOM	115.25	0.32
24	NHLAK600020803-08	SHAW POND	FREEDOM	14.57	0.04
25	NHLAK600020804-01-01	BERRY BAY	FREEDOM	112.12	0.31
26	NHLAK600020804-01-02	LEAVITT BAY	OSSIPEE	68.11	0.19
27	NHLAK600020804-01-03	BROAD BAY	FREEDOM	61.68	0.17
28	NHLAK600020902-01	PROVINCE LAKE	EFFINGHAM	44.74	0.12
29	NHLAK600021001-01	BALCH POND	WAKEFIELD	100.05	0.27
30	NHLAK600030403-02	HORN POND	WAKEFIELD	23.94	0.07
31	NHLAK600030601-05-01	SUNRISE LAKE	MIDDLETON	55.94	0.15
32	NHLAK600030602-03	ROCHESTER RESERVOIR	ROCHESTER	-34.66	-0.09
33	NHLAK600030605-01	NIPPO POND	BARRINGTON	12.26	0.03
34	NHLAK600030704-02-01	PAWTUCKAWAY LAKE	NOTTINGHAM	7.50	0.02
35	NHLAK600030802-01	HUNT POND	SANDOWN	-47.88	-0.13
36	NHLAK700010104-02	LOON POND	LINCOLN	-35.15	-0.10
37	NHLAK700010205-01	MIRROR LAKE	WOODSTOCK	27.29	0.07
38	NHLAK700010304-04	MCCUTCHEON POND	DORCHESTER	-38.88	-0.11
39	NHLAK700010304-05	POUT POND	DORCHESTER	-11.24	-0.03
40	NHLAK700010401-03	CONE POND	THORNTON	-42.19	-0.12
41	NHLAK700010402-03	LOWER HALL POND	SANDWICH	5.94	0.02
42	NHLAK700010402-05	UPPER HALL POND	SANDWICH	-21.15	-0.06
43	NHLAK700010402-08	LITTLE PERCH POND	CAMPTON	-15.31	-0.04
44	NHLAK700010501-01	BARVILLE POND	SANDWICH	54.51	0.15
45	NHLAK700010501-02	INTERVALE POND	SANDWICH	25.17	0.07
46	NHLAK700010501-03	KUSUMPE POND	SANDWICH	16.69	0.05
47	NHLAK700010502-04	SKY POND	NEW HAMPTON	6.24	0.02
48	NHLAK700010701-03	ORANGE POND	ORANGE	46.89	0.13
49	NHLAK700010701-05	WAUKEENA LAKE	DANBURY	53.52	0.15
50	NHLAK700010702-02	SCHOOL POND	DANBURY	40.56	0.11
51	NHLAK700010802-03-01	HERMIT LAKE	SANBORNTON	-141.86	-0.39
52	NHLAK700010802-04	RANDLETT POND	MEREDITH	10.08	0.03
53	NHLAK700010802-05	MOUNTAIN POND	SANBORNTON	-17.91	-0.05
54	NHLAK700010804-01-01	HIGHLAND LAKE	ANDOVER	52.66	0.14
55	NHLAK700010804-02-01	WEBSTER LAKE	FRANKLIN	20.53	0.06
56	NHLAK700020101-05-01	LAKE WENTWORTH	WOLFEBORO	25.61	0.07
57	NHLAK700020101-07-01	RUST POND	WOLFEBORO	71.86	0.20
58	NHLAK700020108-02-01	LAKE WAUKEWAN	MEREDITH	48.69	0.13
59	NHLAK700020108-02-02	LAKE WINONA	NEW HAMPTON	46.35	0.13
60	NHLAK700020108-04	HAWKINS POND	CENTER HARBOR	30.88	0.08
61	NHLAK700020110-02-01	PAUGUS BAY	LACONIA	31.60	0.09
62	NHLAK700020110-02-19	LAKE WINNIPESAUKEE	ALTON	33.94	0.09

Table 1. Critical Loads of Acidity for New Hampshire Acid-Impaired Ponds

Count	Pond ID	Pond Name	Town	Yearly Critical Load meq/m^2/yr	Daily Critical Load meq/m^2/day
63	NHLAK700020110-05	SALTMARSH POND	GILFORD	-73.88	-0.20
64	NHLAK700020201-05-01	LAKE WINNISQUAM	LACONIA	71.90	0.20
65	NHLAK700020202-03	POUT POND	BELMONT	23.43	0.06
66	NHLAK700020202-04	SARGENT LAKE	BELMONT	-64.52	-0.18
67	NHLAK700030101-08	GRASSY POND	RINDGE	-49.27	-0.13
68	NHLAK700030101-12	POOL POND	RINDGE	-61.13	-0.17
69	NHLAK700030101-13	BULLET POND	RINDGE	-51.35	-0.14
70	NHLAK700030103-02	TOLMAN POND	NELSON	27.43	0.08
71	NHLAK700030103-03	JUGGERNAUT POND	HANCOCK	-17.78	-0.05
72	NHLAK700030103-09	SPOONWOOD LAKE	NELSON	5.60	0.02
73	NHLAK700030103-10	DINSMORE POND	HARRISVILLE	18.30	0.05
74	NHLAK700030105-01-01	ZEPHYR LAKE	GREENFIELD	12.73	0.03
75	NHLAK700030105-02-01	OTTER LAKE	GREENFIELD	-35.03	-0.10
76	NHLAK700030105-03-01	SUNSET LAKE	GREENFIELD	-118.72	-0.33
77	NHLAK700030107-01	WILLARD POND	ANTRIM	-28.15	-0.08
78	NHLAK700030202-06	BAGLEY POND	WINDSOR	-0.71	0.00
79	NHLAK700030203-02	SMITH POND	WASHINGTON	27.60	0.08
80	NHLAK700030203-03	TROUT POND	STODDARD	-29.99	-0.08
81	NHLAK700030204-04	LOON POND	HILLSBOROUGH	16.59	0.05
82	NHLAK700030302-02	BLAISDELL LAKE	SUTTON	49.13	0.13
83	NHLAK700030302-04-01	MASSASECUM LAKE	BRADFORD	-78.22	-0.21
84	NHLAK700030304-05	TOM POND	WARNER	32.30	0.09
85	NHLAK700030304-07	TUCKER POND	SALISBURY	21.49	0.06
86	NHLAK700030304-08	LAKE WINNEPOCKET	WEBSTER	27.70	0.08
87	NHLAK700030401-02	BUTTERFIELD POND	WILMOT	-29.95	-0.08
88	NHLAK700030402-01	CHASE POND	WILMOT	2.45	0.01
89	NHLAK700030402-02-01	PLEASANT LAKE	NEW LONDON	-30.47	-0.08
90	NHLAK700030403-05	HORSESHOE POND	ANDOVER	145.10	0.40
91	NHLAK700030502-03	BEAR POND	WARNER	42.58	0.12
92	NHLAK700030505-01	CLEMENT POND	HOPKINTON	80.90	0.22
93	NHLAK700040401-01-01	MELENDY POND	BROOKLINE	-5.89	-0.02
94	NHLAK700040401-02-01	POTANIPO POND	BROOKLINE	17.25	0.05
95	NHLAK700060101-01	SHAW POND	FRANKLIN	-4.91	-0.01
96	NHLAK700060101-02-01	SONDOGARDY POND	NORTHFIELD	1.40	0.00
97	NHLAK700060201-01-01	LOON POND	GILMANTON	81.22	0.22
98	NHLAK700060201-03	NEW POND	CANTERBURY	6.10	0.02
99	NHLAK700060202-03-01	CLOUGH POND	LOUDON	40.80	0.11
100	NHLAK700060202-04	CROOKED POND	LOUDON	21.02	0.06
101	NHLAK700060401-02-01	CRYSTAL LAKE	GILMANTON	-1.01	0.00
102	NHLAK700060401-06	MANNING LAKE	GILMANTON	27.14	0.07
103	NHLAK700060401-12	SUNSET LAKE	ALTON	8.08	0.02
104	NHLAK700060402-03	HALFMOON LAKE	ALTON	17.96	0.05
105	NHLAK700060402-05	HUNTRESS POND	BARNSTEAD	12.90	0.04
106	NHLAK700060403-01	BIG WILLEY POND	STRAFFORD	-39.06	-0.11
107	NHLAK700060403-02	LITTLE WILLEY POND	STRAFFORD	-25.88	-0.07
108	NHLAK700060501-03	WILD GOOSE POND	PITTSFIELD	-3.19	-0.01
109	NHLAK700060501-08	BERRY POND	PITTSFIELD	16.26	0.04
110	NHLAK700060502-03	CHESTNUT POND	EPSOM	20.17	0.06
111	NHLAK700060503-01	BEAR HILL POND	ALLENSTOWN	-39.11	-0.11
112	NHLAK700060601-01	DEERING RESERVOIR	DEERING	7.51	0.02
113	NHLAK700060601-02	DUDLEY POND	DEERING	30.86	0.08
114	NHLAK700060601-03-01	PLEASANT POND	HENNIKER	64.98	0.18
115	NHLAK700060602-02	MOUNT WILLIAM POND	WEARE	16.26	0.04
116	NHLAK700060604-01	PLEASANT POND	FRANCESTOWN	-7.74	-0.02
117	NHLAK700060607-03	LONG POND	DUNBARTON	-10.05	-0.03
118	NHLAK700060702-03	MASSABESIC LAKE	AUBURN	-32.64	-0.09
119	NHLAK700060802-02	LAKINS POND	HOOKSETT	-10.32	-0.03
120	NHLAK700060802-03	PINNACLE POND	HOOKSETT	-31.73	-0.09
121	NHLAK700060803-02	STEVENS POND	MANCHESTER	-1659.62	-4.55
122	NHLAK700061002-03	HORSESHOE POND	MERRIMACK	-209.09	-0.57
123	NHLAK700061101-01-01	ISLAND POND	HAMPSTEAD	103.57	0.28
124	NHLAK700061203-06-01	ROBINSON POND	HUDSON	93.60	0.26

Table 1. Critical Loads of Acidity for New Hampshire Acid-Impaired Ponds

Count	Pond ID	Pond Name	Town	Yearly Critical Load $meq/m^2/yr$	Daily Critical Load $meq/m^2/day$
125	NHLAK700061204-02	LITTLE ISLAND POND	PELHAM	58.97	0.16
126	NHLAK700061204-03	ROCK POND	WINDHAM	88.45	0.24
127	NHLAK700061205-01	GUMPAS POND	PELHAM	24.41	0.07
128	NHLAK801010102-03	ROUND POND	PITTSBURG	243.66	0.67
129	NHLAK801010707-01-01	CHRISTINE LAKE	STARK	38.40	0.11
130	NHLAK801040201-03	LAKE TARLETON	PIERMONT	5.44	0.01
131	NHLAK801040203-01-01	POST POND	LYME	221.54	0.61
132	NHLAK801060101-03	CUMMINS POND	DORCHESTER	-6.28	-0.02
133	NHLAK801060101-05	RESERVOIR POND	DORCHESTER	-1.57	0.00
134	NHLAK801060103-02	LITTLE GOOSE POND	CANAAN	43.57	0.12
135	NHLAK801060104-02	GRAFTON POND	GRAFTON	31.64	0.09
136	NHLAK801060401-06	EASTMAN POND	GRANTHAM	-22.54	-0.06
137	NHLAK801060401-08-01	KOLELEMOOK LAKE	SPRINGFIELD	-28.75	-0.08
138	NHLAK801060402-04-01	LITTLE SUNAPEE LAKE	NEW LONDON	-112.24	-0.31
139	NHLAK801060402-05-01	SUNAPEE LAKE	SUNAPEE	32.77	0.09
140	NHLAK801060402-11	MOUNTAINVIEW LAKE	SUNAPEE	-213.60	-0.59
141	NHLAK801060402-12-01	OTTER POND	SUNAPEE	61.19	0.17
142	NHLAK801060403-01	GILMAN POND	UNITY	21.76	0.06
143	NHLAK801060403-04-01	RAND POND	GOSHEN	53.96	0.15
144	NHLAK801060404-01	ROCKYBOUND POND	CROYDON	45.88	0.13
145	NHLAK801070201-01	CRESCENT LAKE	CRESCENT LAKE	11.07	0.03
146	NHLAK801070503-01-01	SPOFFORD LAKE	CHESTERFIELD	74.44	0.20
147	NHLAK802010102-05	BARRETT POND	WASHINGTON	-36.60	-0.10
148	NHLAK802010104-01	CALDWELL POND	ALSTEAD	-40.21	-0.11
149	NHLAK802010104-03	CRANBERRY POND	ALSTEAD	-42.27	-0.12
150	NHLAK802010202-02	CHILDS BOG	HARRISVILLE	-50.40	-0.14
151	NHLAK802010202-07	RUSSELL RESERVOIR	HARRISVILLE	-50.97	-0.14
152	NHLAK802010202-14	BABBIDGE RESERVOIR	ROXBURY	3.25	0.01
153	NHLAK802010302-01-01	SWANZEY LAKE	SWANZEY	55.65	0.15
154	NHLAK802010303-02	MEETINGHOUSE POND	MARLBOROUGH	-36.11	-0.10
155	NHLAK802010303-07	SAND POND	TROY	-0.44	0.00
156	NHLAK802010303-10	WILSON POND	SWANZEY	23.98	0.07
157	NHLAK802020103-04	EMERSON POND	RINDGE	-10.40	-0.03
158	NHLAK802020202-01	COLLINS POND	FITZWILLIAM	-38.20	-0.10